Project Introduction

Since illnesses and injury during space flight pose risks both to crew health and to mission objectives during Space Exploration, these risks must be minimized in multiple ways (e.g., selection criteria, preventative measures, flying appropriate hardware, and procedures). Under this task, the principal investigator produced a software-based decision support tool using an evidence-based approach to delineate clinical strategies for minimizing risks to crew health during space missions.

The Integrated Medical Model (IMM) is designed to identify and quantify crew health risks during flight and to evaluate the effectiveness of in-flight mitigation strategies. The IMM integrates terrestrial and space flight evidence bases to quantify the probability and the consequences of in-flight medical risks using Monte Carlo simulations. Utilizing well accepted scenario driven techniques, such as probabilistic risk analysis, as a guide, IMM generates a set of quantitative measures, such as mission time lost, probability of crew evacuation, and probability of loss of crew life, to enable decision makers to make objective assessment of crew health and mission outcomes with respect to our current level of knowledge.

The current IMM can be used to optimize in-flight medical system capabilities, manage science and technology development portfolios, prioritize crew medical training, and support a variety of "what if" scenarios posed by mission planners. The latest version of the model, IMM 3.0, includes a SQL database and Reference Manager central library, which quantify and document all the clinical evidence used by the IMM.

This interdisciplinary research effort included the establishment of a conceptual framework, the development of an extensive input dataset and SQL database, the development of external models, the creation of simulation and optimization model software, and the design and implementation of novel verification, validation, and configuration management processes.

OBJECTIVES

The IMM Project was tasked to develop an evidence-based, probabilistic decision support tool and integrate the tool in the decision making processes of customers within the Space Life Sciences Directorate (SLSD). The five key objectives of the IMM Project support these overarching goals: 1) develop a software-based, stochastic decision support tool useful to clinical stakeholders and medical mission planners; 2) develop a knowledge management tool for the clinical evidence used by the model; 3) update the medical risk estimates of the Probabalistic Risk Assessment model used by the International Space Station (ISS) Program; 4) develop the ability to optimize the mass and volume for an in-flight medical system and specified level of risk; and 5) help close the communication gaps among science, clinical operations, and engineering communities.

Integrated Medical Model (IMM)

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Anticipated Benefits

The IMM, a product of six years of research, development, and testing, provides NASA a flexible decision support tool for managing human performance and health risks in the harsh, resource-constrained environment of space. The IMM may also find applications in the emerging commercial space flight industry, military missions, maritime and aviation industries, or other remote operations where resources are limited and definitive medical care is not readily available.

The ability to categorize health threats according to crew physiology, crew activities, mission tempo, and mission environment enables prioritized training, space flight systems development, and procedures that result in positive health and mission impacts. IMM can provide a defensible position for making cost-effective decisions regarding crew health, and will help achieve mission success by focusing limited funds on the most relevant health care policies, protocols, and technologies.

Primary U.S. Work Locations and Key Partners
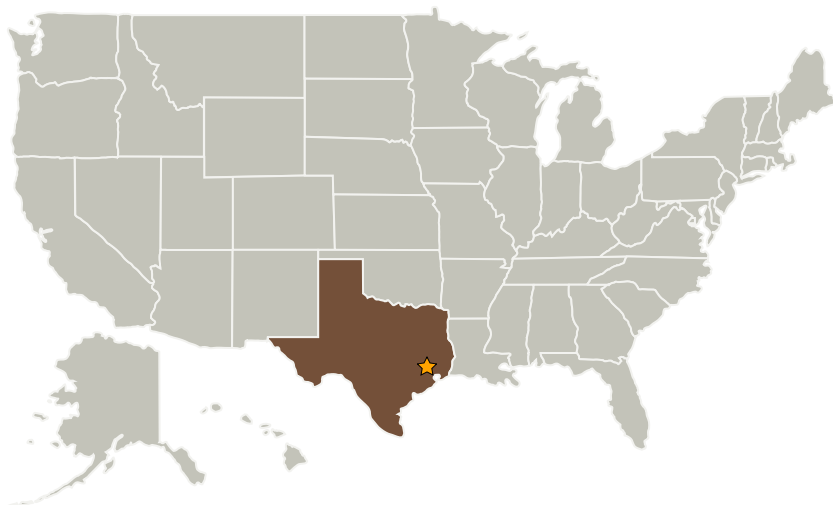
Organizational Responsibility

Responsible Mission Directorate:
Space Operations Mission Directorate (SOMD)

Lead Center / Facility:
Johnson Space Center (JSC)

Responsible Program:
Human Spaceflight Capabilities

Project Management

Program Director:
David K Baumann

Project Manager:
Sharmila D Watkins

Principal Investigator:
Douglas J Butler

Co-Investigators:
Mary H Freire De Carvalho
Lynn Saile
Vilma T Lopez
Sam Strauss
Eric L Kerstman
Grandin B Bickham
Marlei E Walton
Jerry G Myers
Madurai S Iyengar
Charles G Minard

| Organizations Performing Work	Role	Type	Location
⭐Johnson Space Center(JSC)	Lead Organization	NASA Center	Houston, Texas
The University of Texas at Austin	Supporting Organization	Academia	Austin, Texas
The University of Texas Medical Branch at Galveston(UTMD-Galv.)	Supporting Organization	Academia	Galveston, Texas
Wyle Integrated Science and Engineering Group	Supporting Organization	Industry	

Primary U.S. Work Locations
Texas

Project Transitions

▶ **October 2005:** Project Start

Technology Maturity (TRL)

Start: **4**
Current: **6**
Estimated End: **6**

1	2	3	4	5	6	7	8	9
Applied Research			Development			Demo & Test		
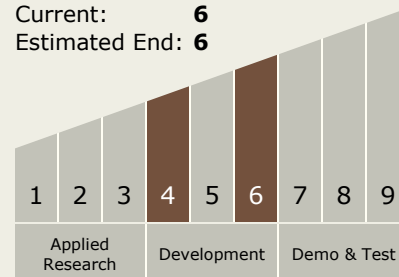
Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  └ TX06.3 Human Health and Performance
    └ TX06.3.1 Medical Diagnosis and Prognosis

Target Destinations

The Moon, Mars

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January 2011: Closed out

Closeout Summary: The IMM project was funded from 1 October 2005 to 31 January 2011, at which point the IMM transitioned to an operational tool used by the International Space Station Program to update evacuation and loss of life risk estimates due crew medical events. During the course of development, validation, and transition to operations, both the model data inputs and outputs have aided a broad set of users address in-flight mission and crew health risks, science portfolio allocations, emergency return scenarios, crew training, and in-flight medical system capabilities. Three key tools created by the IMM Project increase SLSD knowledge management, research, and operational capabilities: 1) IMM Central Library - The IMM Central Library houses all citations and references used to form the clinical basis for each medical condition represented in the IMM. This central library creates the foundation for the SLSD Enterprise-wide Library Solution; 2) IMM Database - The IMM Database is accessible by the SLSD science and clinical operations community. Custom-designed reports can be tailored for each user while automatic notifications will ensure they are aware of the latest additions or alternations; and 3) IMM - The evidence-based, analytic representation of in-flight crew health risk -- in the context of a specific mission and crew profile -- provides an unprecedented capability to communicate clinical risk in engineering-centric programs. The IMM also provides an objective foundation for mission planning dialogue based on evidence and all available relevant data sources.

Stories

Articles in Peer-reviewed Journals
(https://techport.nasa.gov/file/53728)

Awards
(https://techport.nasa.gov/file/53730)

NASA Technical Documents
(https://techport.nasa.gov/file/53732)

Papers from Meeting Proceedings
(https://techport.nasa.gov/file/53734)

Project Website:

https://taskbook.nasaprs.com